

## Brief status update on Fast Sim for calorimeter response

Kurt Hill  
Ron Belmont

University of Colorado, Boulder

March 22<sup>nd</sup>, 2016

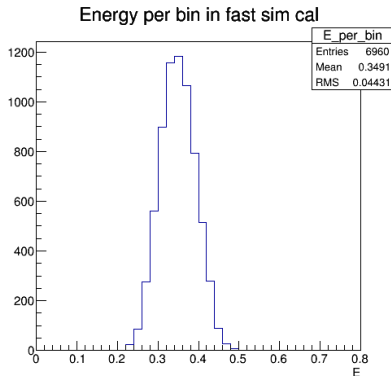


- To reduce cost, the tracker readout for the outer layers may be ganged
- This causes a significant reduction in tracking purity (high fake rate)
- In principle, calorimeter cuts can be applied to reduce contamination from fake tracks
- Full GEANT simulations of calorimeters are extremely time- and resource-consuming
- A fast simulation achieved through simplistic calorimeter modeling can be employed for quicker, less resource intensive studies

- Calorimeter model is a PHG4CylinderSubsystem with “BlackHole” enabled
  - This means each particle leaves all its energy in a single hit in the volume
  - All the standard truth level information is available from this hit: PID, energy, position, etc.
- The total energy is smeared and distributed to neighboring towers
  - The energy resolution and spatial smearing are parameterized based on full G4 single particle simulations
  - More details on the smearing in the backup slides
- Parameters:
  - Radius = 120 cm (inner HCal inner radius is 115 cm)
  - Energy threshold to deposit any energy = 10 MeV
  - Energy threshold to distribute energy to multiple towers = 500 MeV

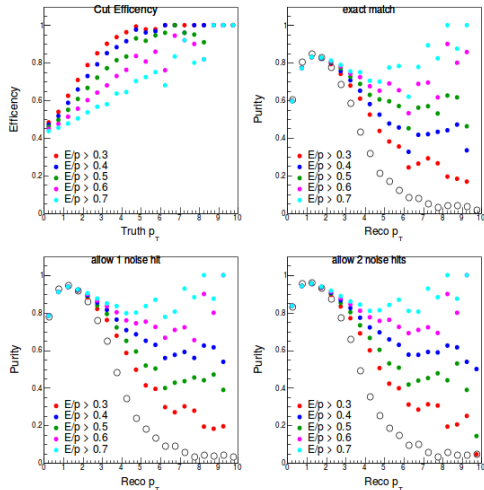
- 20,000 HIJING 200 GeV Au+Au events,  $0 < b < 4$  fm (approx. 0–5% central)
- Track configuration: pixels+strips (2 pixel layers and 5 strip layers) with strip outputs ganged together
- Tracker-calorimeter association: sPHENIX software default
- Energy variables used: `SvtxTrack::get_cal_energy_3x3()`
  - In central A+A collisions the current clustering algorithm may not work (potentially all towers would be grouped into a single cluster)
- Calorimeter cuts are  $E/p > X$  where  $p$  is the momentum from the tracker and  $E$  energy from the calorimeter with the pedestal subtracted

- In principle one needs to remove the background energy (pedestal) when trying to isolate specific tracks using the calorimeter
- We determine the average energy per tower per event—found to be 0.349 GeV per tower, 3.14 GeV for each 3x3 cluster



# Purity with $E/p$ cuts

- Efficiency and purity for various  $E/p$  cuts
- Ganged output severely harms purity for  $p_T > 3 \text{ GeV}/c$
- Calorimeter cuts significantly improve the purity, mitigating the harm done by the ganged outputs
- A harsh but plausible  $E/p > 0.7$  cut keeps purity above 80% for all  $p_T$  and has efficiency above 50% for  $p_T > 3 \text{ GeV}/c$
- Note, however, the behavior for all cuts may have significant non-monotonicity in  $p_T$



## Summary

- We have successfully developed a fast sim to model calorimeter performance
- Our results show that calorimeter cuts can mitigate the problems caused by ganged output on the outer tracker layers

## Outlook

- There's plenty of room for improvement in the implementation, as one can always add more details
- Short term next steps could be as simple as running the same simulation over other tracker configurations
- We've ignored electrons so far, but these are of course extremely interesting (expert guidance very welcome)
- Any ideas, suggestions, recommendations, etc. from the experts are all welcome

Unfortunately, there's one more thing to discuss...



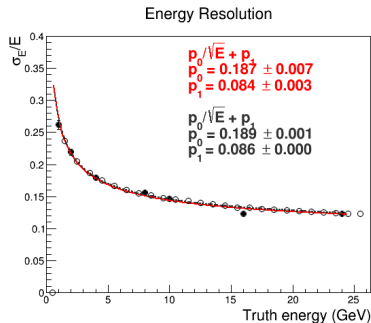
- Achim informs both of us that our jobs are sometimes crashing with severe excess memory usage, and he's getting a lot of emails from RACF
- He suggested independently, as we had already discussed earlier with Jin, to use the special high memory rcas nodes for job submission
- This is a little disappointing, since part of the goal of the fast sim is to not have to do that
- However, we both have observed that even when running the tracking simulation only with no calorimeter at all that sometimes the jobs still get held for excess memory usage, so maybe the regular rcas nodes just aren't up to the task of dealing with centra HIJING
- Should we start running on these special nodes?



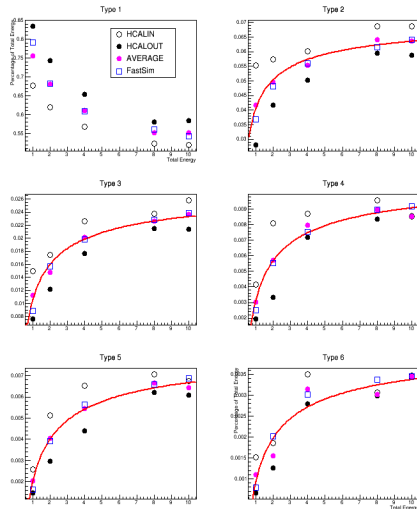
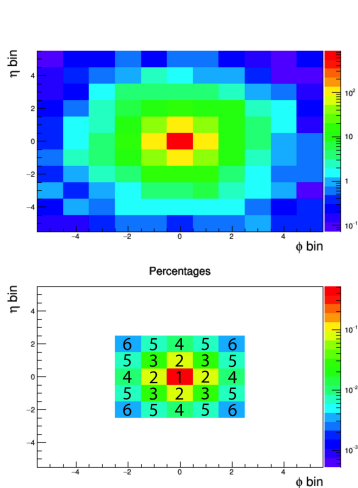
Extra material

# Energy resolution

- Studied energy resolution in full G4 single particle simulation
- Truth energy smeared to match resolution based on parameterization
- Closure—resolution of fast sim output very closely matches input

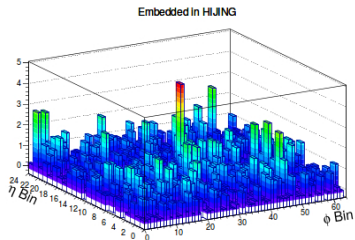
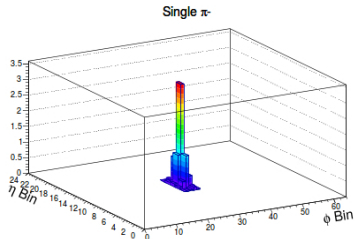
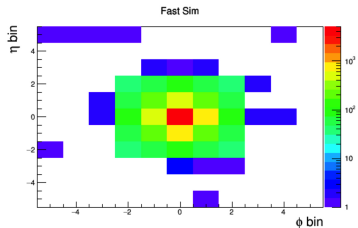
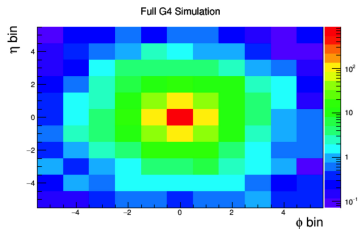


# Spatial distributions



- Average tower distribution of energy studied in full G4 single particle simulations
- Energy in each tower is interpolated across the available full G4 sim energies
- Satellite towers selected randomly based on parameterization, central tower selected based on the rest of the towers (energy conservation)

# Spatial distributions



- Closure—measured distribution from sim output closely matches input
- Comparison figure shows single pion and single pion embedded in HIJING, both using fast sim